ECEN 250 Lab7 – Transformers

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Purposes:

- Simulate the behavior of transformers used to drive a resistive load
- Calculate the Thevenin equivalent values of simulated transformers
- Use lab equipment to evaluate an audio transformer to drive a resistive load
- Calculate the Thevenin equivalent values of the actual transformer circuit
- Make observations on practical uses of transformers to drive loads

Procedure:

Part 1a - SPICE simulation of a transformer with a 6:1 turns ratio

Simulate the following circuit in LTspice:

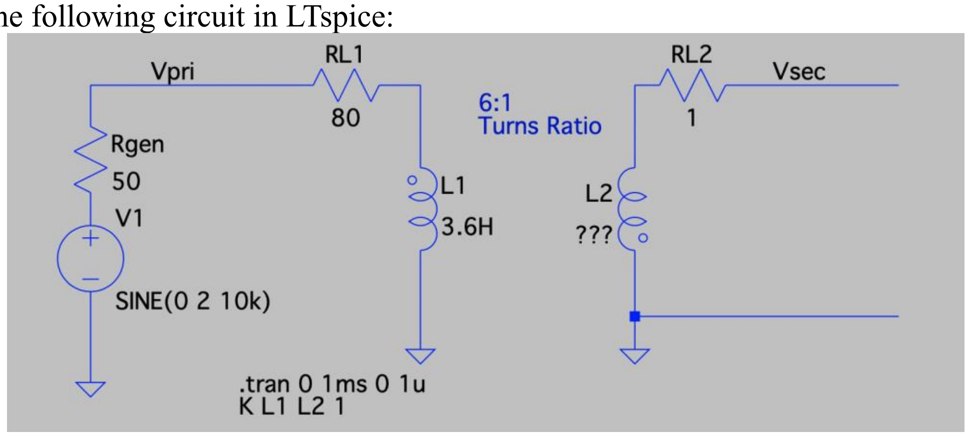
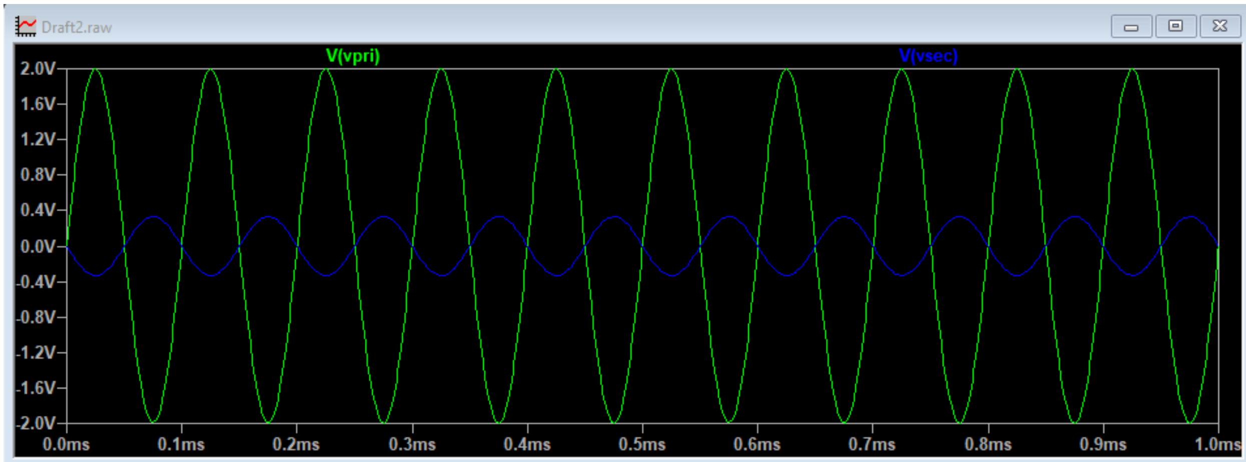
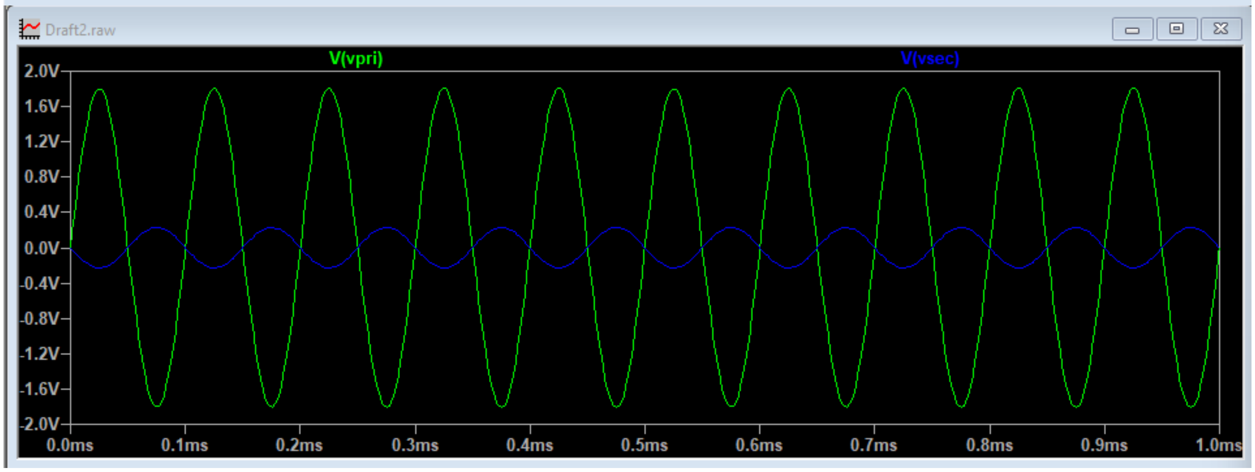


Figure 1a - A SPICE schematic of a 6:1 transformer

If $\frac{N_2}{N_1} = \sqrt{\frac{L_2}{L_1}}$ in an ideal transformer, what inductance should L2 be for a 6:1 turns ratio?________0.1 H__________

Simulate to verify proper turns ratio, then simulate with a 10 Ω load. Place a screenshot of your simulations below (display *Vpri*, and *Vsec*):





Complete the table with and without a resistive load:

No Load		10 Ω Load	
Vpri (p-p)	*Vsec (p-p)*	*Vpri (p-p)*	*Vsec (p-p)*
4V	0.66V	1.8V	0.6V

Any linear circuit can be represented by a Thevenin equivalent circuit. It is easy to calculate the V_{th} and R_{th} values. V_{th} is the output voltage when there is no load applied. *Rth* may be calculated from the output voltage when a load resistance, R_{load}, is applied to the output (V_{loaded}):

$$V_{loaded} = V_{th} \frac{R_{load}}{R_{th} + R_{load}}$$

Note: If there is appreciable phase shift when the load resistance is applied, we would need to calculate Z_{th} instead of R_{th}. We are assuming there is little to no phase shift.

- What is V_{th}? 0.66V
- What is R_{th}? 1.01 ohms

Repeat the simulation reversing the windings of the transformer (swap inductor values and winding resistances):

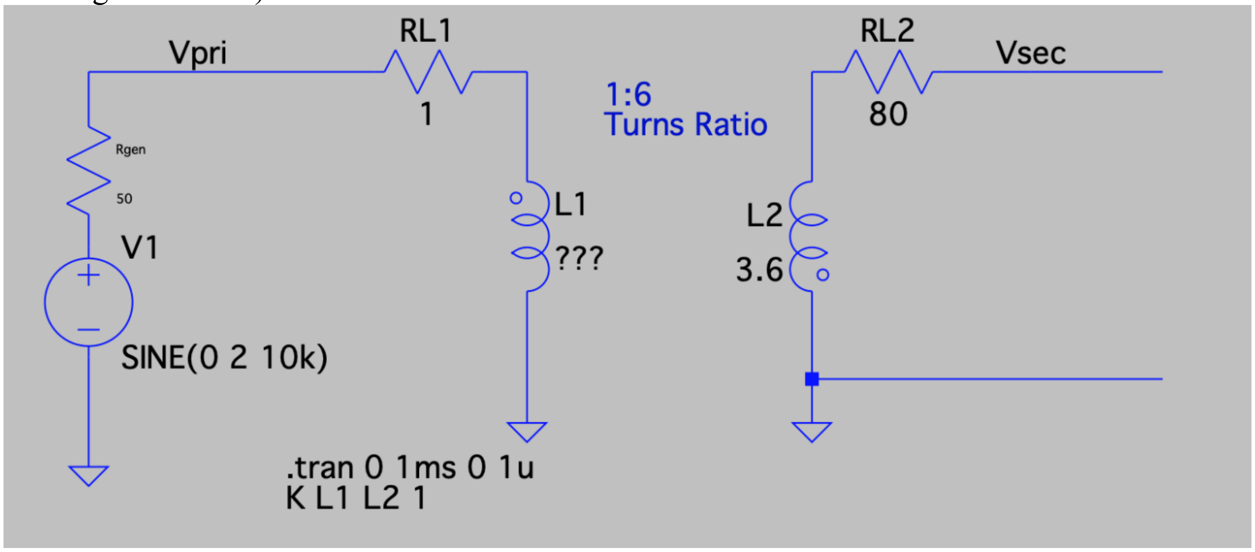
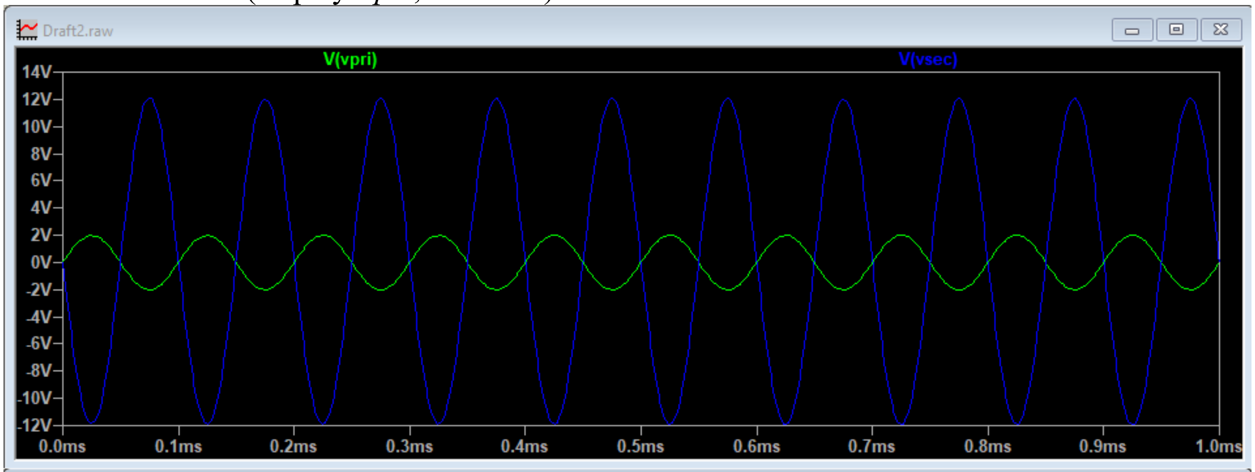
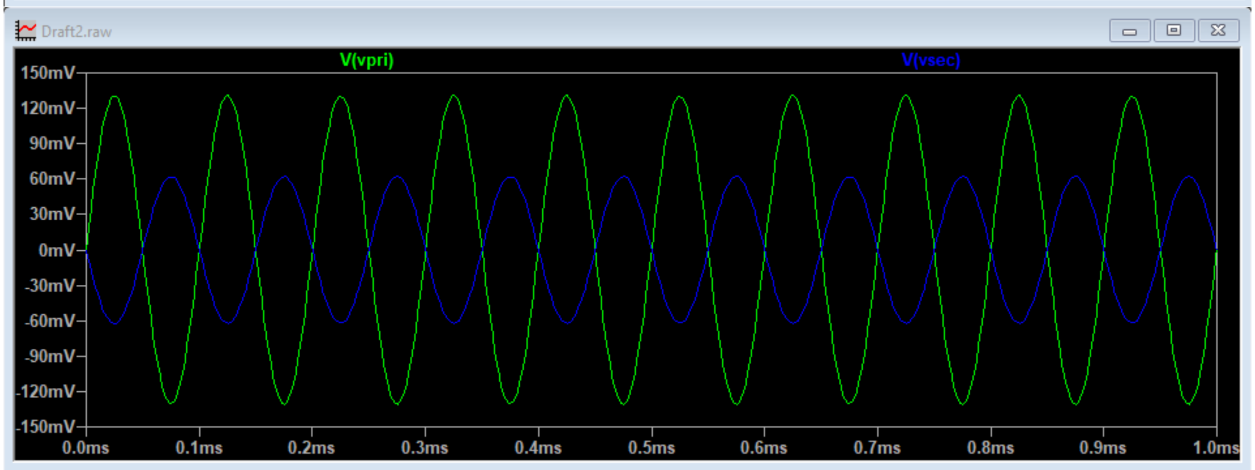


Figure 1b - A SPICE schematic of a 1:6 transformer

Simulate to verify proper turns ratio, then simulate with a 10 Ω load. Place a screenshot of your simulations below (display *Vpri*, and *Vsec*):





Complete the table with and without a resistive load:

No Load		10 Ω Load	
Vpri (p-p)	*Vsec (p-p)*	*Vpri (p-p)*	*Vsec (p-p)*
4V	24V	0.27V	0.12V

- What is V_{th}? 24V
- What is R_{th}? 1990 ohms

Part 3 - Construct the physical circuit and make measurements

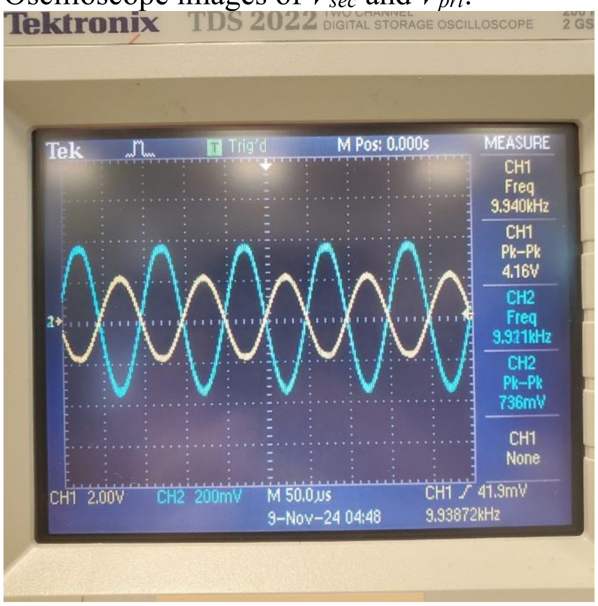
Measure the turns-ratio of each of the transformers at 10KHz:

Assume $\frac{N_2}{N_1} = \frac{V_{sec}}{V_{pri}}$ and normalize the turns ratio (4.0:0.69 becomes 5.8:1)

	V_{pri} (target $4V_{p\text{-}p}$)	V_{sec} (p-p)	Turns-ratio N_1:N_2
T1	4.0V	4.0V	1:1
T2	4.24V	1.5V	2.8:1
T3	4.24V	0.78V	5.4:1
T4	4.24V	0.32V	13.1:1

Using the transformer with the turns-ratio closest to 6:1, construct the circuit of Part 1a and make the same measurements using lab equipment (don't add the two resistors RL1 and RL2, because these represent the winding resistance).

Oscilloscope images of V_{sec} and V_{pri}:



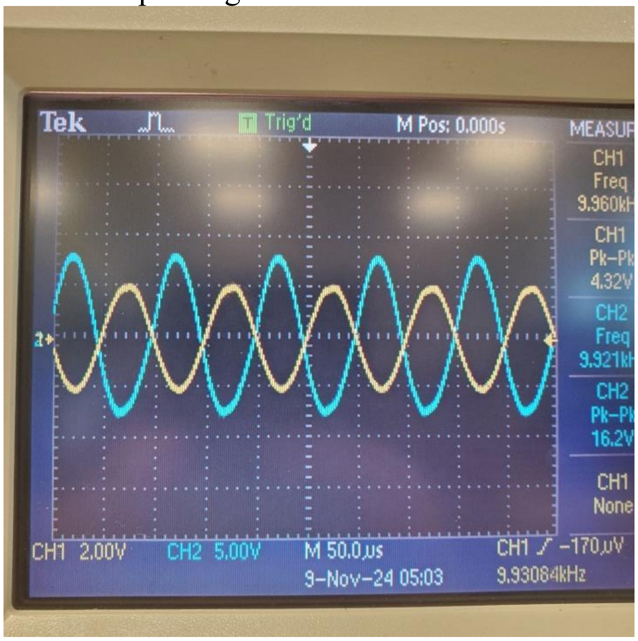
Complete the table with and without a resistive load:

No Load		10 Ω Load	
Vpri (p-p)	Vsec (p-p)	Vpri (p-p)	Vsec (p-p)
4.24V	0.78V	3.88V	0.59V

- What is V_{th}? 0.78V
- What is R_{th}? 3.17 ohms

Construct the circuit of Part 1b and make the same measurements using lab equipment.

Oscilloscope images:



Complete the table with and without a resistive load:

No Load		10 Ω Load	
Vpri (p-p)	*Vsec (p-p)*	*Vpri (p-p)*	*Vsec (p-p)*
4.24V	16.4V	2.88V	1.1V

- What is V_{th}? 16.4V
- What is R_{th}? 131 ohms

Conclusions (write a conclusion statement that discusses each of the purposes of the lab):

In this lab, we used both simulations and built a physical circuit to understand the behavior of transformers better. We simulated and measured, using an oscilloscope, the voltage across a load and calculated to Thevenin voltage when there was no load. This allowed us to understand what the equivalent circuit is doing better. From this lab it also helped us understand the uses of transformers. They are great at stepping up or stepping down voltage at the cost of current which can be used in many ways, such as efficiently delivering power long distances before stepping it down to drive a resistive load with higher current.